

Signal-to-noise (S/N) calculators

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Let's do some simple math, first...

Simple example of S/N calculation

S: signal

N: noise = \sqrt{S} following Poisson statistics

n: signal rate [counts/second]

t: exposure time [seconds]

n_B : background signal rate [counts/second]

R: detector noise [counts]

This is the signal you look for: $S=nt$

This is the signal you measure: $S= nt + n_B t$

There are 3 main noise sources:

$$N_1=\sqrt{(nt+n_B t)} \quad N_2=\sqrt{(n_B t)} \quad N_3=R$$

Total noise:

$$\begin{aligned} N &= \sqrt{N_1^2 + N_2^2 + N_3^2} \\ &= \sqrt{nt + n_B t + n_B t + R^2} \end{aligned}$$

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t: exposure time [seconds]

n_B : background signal rate [counts/second]

R: detector noise [counts]

$$\frac{S}{N} = \frac{nt}{\sqrt{nt + n_B t + n_B t + R^2}} = \frac{nt}{\sqrt{nt \left(1 + \frac{2n_B}{n} + \frac{R^2}{nt}\right)}} = \frac{\sqrt{nt}}{\sqrt{1 + \frac{2n_B}{n} + \frac{R^2}{nt}}}$$

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$$= \sqrt{nt + n_B t + n_B t + R^2}$$

$$\frac{S}{N} = \frac{nt}{\sqrt{nt + n_B t + n_B t + R^2}} = \frac{nt}{\sqrt{nt \left(1 + \frac{2n_B}{n} + \frac{R^2}{nt}\right)}} = \frac{\sqrt{nt}}{\sqrt{1 + \frac{2n_B}{n} + \frac{R^2}{nt}}}$$

1) If $n_B \ll 1$ and $R \ll 1$, then: $\frac{S}{N} = \sqrt{nt} = \frac{S}{\sqrt{S}}$ Poisson noise

2) Increasing t decreases the impact of R on the noise budget

3) If $n_B \gg 1$ and $n_B \gg R$ (background dominated), then:

$$\frac{S}{N} \sim \frac{\sqrt{nt}}{\sqrt{2n_B/n}} = \frac{n\sqrt{t}}{\sqrt{2n_B}}$$

The S/N increases as \sqrt{t}

4) If $R \gg n_B$ and $R \gg 1$ (detector noise dominated), then:

$$\frac{S}{N} \sim \frac{\sqrt{nt}}{\sqrt{R^2/nt}} = \frac{nt}{R}$$

The S/N increases as t

Possibly useful equation

T_0 : reference exposure time

V_0 : reference magnitude

$(S/N)_0$: reference S/N

t : exposure time

V : magnitude

In a regime that is neither background dominated nor detector noise dominated

$$t = T_0 \times 10^{\frac{V - V_0}{2.5}} \left(\frac{S/N}{(S/N)_0} \right)^2 + \text{overheads}$$

Knowing the $(S/N)_0$ reached for a target of a given magnitude V_0 and for a given exposure time T_0 , this equation allows you to quickly derive the exposure time t needed to reach a certain S/N for a different target of magnitude V , and thus the total telescope time if one adds the *overheads*.

Exposure time calculator (ETC)

Estimate the S/N through exposure time calculators (ETCs) has to be an integral part of selecting the telescope and instrument to use for a given observation.

Each instrument/facility has its own ETC tool, which is typically available through a web interface.

Running the ETC requires prior good knowledge of the instrument and its characteristics. Therefore, get to know the basic characteristics of an instrument before running its ETC.

ETC: typical inputs

Target properties:

- Shape of the spectral energy distribution
- Magnitude

ESO

<input checked="" type="radio"/> Template Spectrum	A0V (Pickles) ▾	Redshift z = <input type="text" value="0.00"/>	<p>Target Magnitude and Mag.System:</p> <p><input type="text" value="V"/> ▾ = <input type="text" value="15.00"/> <input checked="" type="radio"/> Vega <input type="radio"/> AB</p> <p><i>Magnitudes are given per arcsec² for extended sources</i></p>
<input type="radio"/> MARCS Stellar Model	Teff=4000 log(g)=-0.5 [Fe/H]= 0 M= 1 ▾		
<input type="radio"/> Upload Spectrum	Select... <input type="text"/>		
<input type="radio"/> Blackbody	Temperature: <input type="text"/> K		
<input type="radio"/> Power Law	Index: <input type="text"/> $F(\lambda) \propto \lambda^{index}$		
<input type="radio"/> Emission Line	Lambda: <input type="text"/> nm Flux: <input type="text"/> 10^{-16} ergs/s/cm ² (per arcsec ² for extended sources) FWHM: <input type="text"/> nm		

Spatial Distribution: ☒ Point Source ☐ Extended Source

ETC: typical inputs

HST

3. Choose one of the following **spectral distributions** for the source:

Please note: for User supplied and uploaded spectrum, please use only FITS or text (DAT) format files.

- ☐ [Upload Spectrum File:](#) No file selected.
- ☐ [Other HST Spectrum:](#)
CDBS Synphot spectrum file
- ☐ [Castelli and Kurucz Models:](#) [Sp Teff log(g) log(z)=0]
- ☐ [Pickles Models:](#) (Sp Teff)
- ☐ [Kurucz Models:](#)
- ☐ [Bruzual Synthetic Stellar Spectra:](#)
- ☐ [HST Standard Star spectra:](#)
- ☐ [Phoenix M dwarf Models:](#)
- ☐ [Non-Stellar Objects:](#)
- ☐ a Black-body with temperature T =
- ☐ a Power-law: $F\lambda = \lambda^{**}$
- ☒ a Flat continuum in
- ☐ No continuum. *If selected, the reference wavelength from part 2 above must correspond to one of the lines; and **no extinction, redshift, or renormalization may be applied.***

Specify the extinction [E\(B-V\)](#) =

Extinction applied normalization.

Specify the [redshift](#) z =

Add emission lines to the input spectrum (optional): **Note: emission lines are added **after** the spectrum has had extinction, renormalization, and redshift applied.**

Line Center	FWHM	Integrated Flux
Å	Å	(erg/cm ² /s)
(vacuum)		
<input type="text" value="0."/>	<input type="text" value="0."/>	<input type="text" value="0."/>
<input type="text" value="0."/>	<input type="text" value="0."/>	<input type="text" value="0."/>
<input type="text" value="0."/>	<input type="text" value="0."/>	<input type="text" value="0."/>

Note: integrated flux units are per arcsec² for extended sources. *All three of the parameters (line center, fwhm and integrated flux) must be specified for an emission line to be included.*

4. **Normalize the target's flux:**

- ☐ (arcsec⁻² for extended sources) at
- ☒ (arcsec⁻² for extended sources) in filter:
 - ☐ Bandpass selected above in Question 1 (for observations)
 - ☒ **Typically select Vega magnitude above**
 - ☐ **Typically select AB magnitude above**
 - ☐
 - ☐
 - ☐
 - ☐
- ☐ Do not Renormalize Point Source Spectrum. *Use only for User Input Spectrum or Calibration Spectra.*

ETC: typical inputs

Sky conditions for ground-based instruments:

- Moon illumination
- Airmass
- Seeing

☒ Moon FLI: Airmass:

☐ Almanac

PWV: mm *Probability > 95% of realising the $PWV \leq 30.0$ mm*

Seeing/Image Quality:

☒ Turbulence Category: *(FWHM of the atmospheric PSF outside the telescope at zenith at 500 nm)*

☐ IQ: arcsec *FWHM at the airmass and reference wavelength*

ETC: typical inputs

Sky conditions for ground-based instruments:

- Moon illumination
- Airmass
- Seeing

☒ Moon FLI: Airmass:

☐ Almanac

PWV: mm *Probability > 95% of realising the PWV \leq 30.0 mm*

Seeing/Image Quality:

☒ Turbulence Category:

☐ IQ: arcsec *FWHM at the airmass and reference wavelength*

<http://catserver.ing.iac.es/staralt/index.php>

Object Visibility – STARALT

Staralt is a program that shows the observability of objects in various ways: either you can plot altitude against time for a particular night (**Staralt**), or plot the path of your objects across the sky for a particular night (**Startrack**), or plot how altitude changes over a year (**Starobs**), or get a table with the best observing date for each object (**Starmult**). For further information, click on the "help" button at the bottom of the page.

Mode	<input type="text" value="Staralt"/>
Night	<input type="text" value="14"/> <input type="text" value="March"/> <input type="text" value="2024"/> or date when the local night starts. <i>Staralt, Startrack only.</i>
Observatory	<input type="text" value="Roque de los Muchachos Observatory (La Palma, Spain)"/> Select one above or specify your own site with this format: Longitude(°E) Latitude(°N) Altitude(metres) UT-offset(hours) Ex.: 289.2767 -30.2283 2725 -4 <input type="text"/>
Coordinates	Formats can be any of these: name hh mm ss \pm dd mm ss name hh:mm:ss \pm dd:mm:ss name ddd.ddd dd.ddd name must be a single word with no dots, avoid using single numbers. Every entry must be in the same format, do not use different formats with different entries. We recommend a maximum of 100 targets per submission. <input type="text" value="20 31 26 +39 56 20"/> Alternatively, you can upload a file with coordinates. You can use the same format as in the TCS catalog . Target names must be single words with no dots. <input type="button" value="Browse..."/> No file selected.
Options	<input type="text" value="Moon distance"/> Included on plot. Moon coordinates at ~02:00 UT. <i>Staralt only.</i> <input type="text" value="10°, X=5.8"/> Min. elevation (or max. airmass X). <i>Starobs, Starmult only.</i> <input type="text" value="GIF [inline]"/> Output format
Submit	<input type="button" value="Retrieve"/> <input type="button" value="Help"/>
Telescope limits	WHT: 89.8° < Altitude < 12° (plot). Targets with +28:57:40>Dec>+28:33:40 won't be accessible when transiting the zenithal blind spot (~0.2° size). INT: 90° < Altitude < 33° (20° if lower shutter raised), -6h < HA < +6, +90°>Dec>-30° 09' 30" (HA-Dec plot - lower shutter raised; lowest altitude-Dec plot).
More	These are other useful resources for planning observations: iObserve , astronomy tools , JSkyCalc , obstools , NOT's visplot .

Sky conditions for ground-based

- Moon illumination
- Airmass
- Seeing

☒ Moon FLI: Airmass:

☐ Almanac

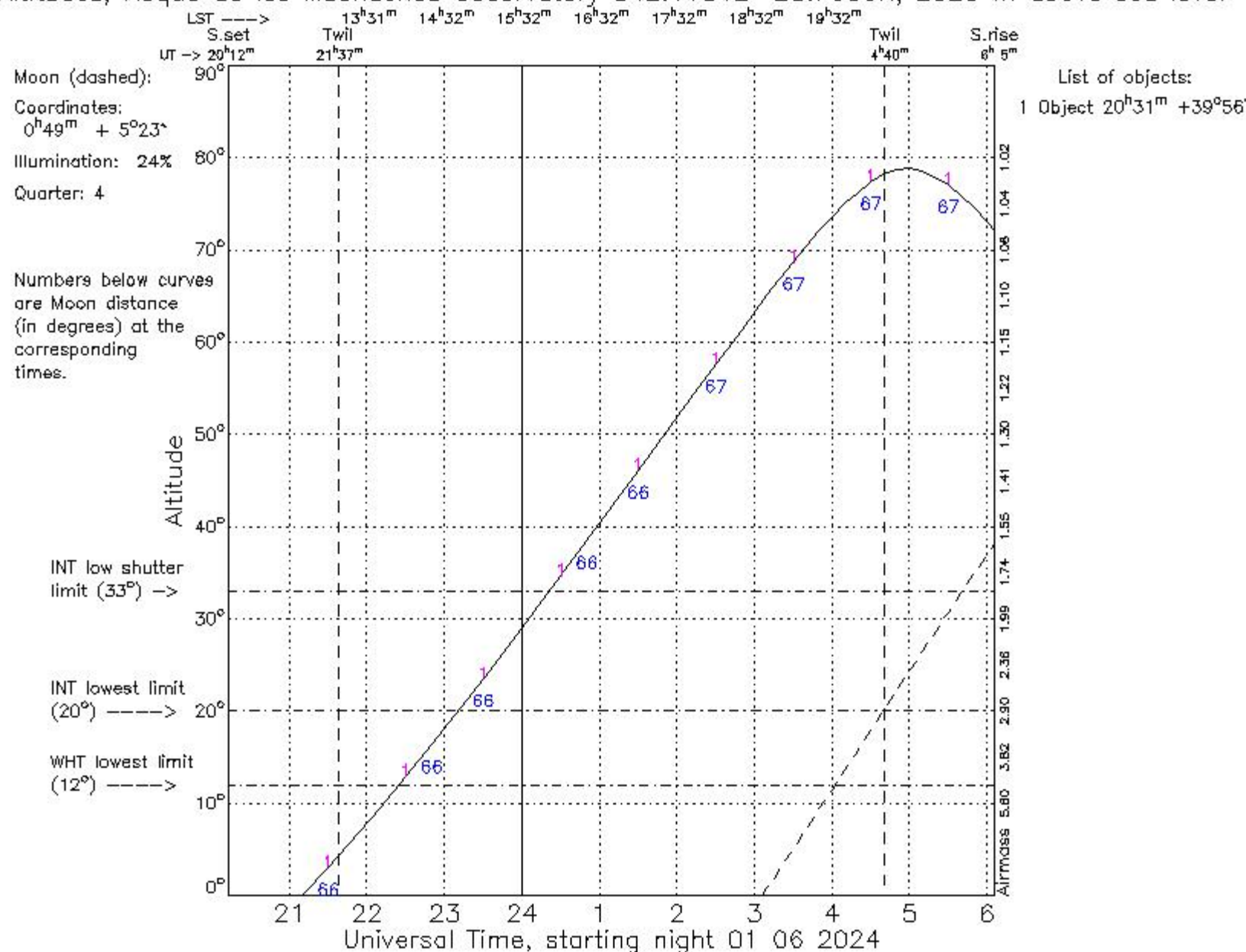
PWV: mm *Probability > 95% of realising*

Seeing/Image Quality:

☒ Turbulence Category: (FWHM)

☐ IQ: arcsec FWHM at the airmass and refi

Altitudes, Roque de los Muchachos Observatory 342.1184E 28.7606N, 2326 m above sea level



ETC: typical inputs

Instrument settings

FORS2 @ ESO

- Resolution:** ☒ Standard
☐ High
- Grism:** GRIS_600B+22 Disp 5.0 nm/mm (0".075/pixel) ▼
- Slit:** 0.40 ▼ arcsec
- Detector:** ☒ MIT red-optimized CCD
☐ E2V blue-optimized CCD
- Readout mode: 100kHz,2x2,high ▼
- Polarimetry:** ☒ No Polarimetry
☐ Linear or Circular Polarisation

STIS on-board HST

1. Select one [Grating/Prism](#) and an associated [Slit/Filter](#):

1st Order CCD

- Grating:** **Cen. Wave.**
- ☐ G750L (5240 - 10265)
- ☐ G750M i 8561 (8275-8847) ▼
- ☐ G430L (2900 - 5700)
- ☒ G430M c 4451 (4308-4594) ▼
- ☐ G230LB (1685 - 3065)
- ☐ G230MB c 1713 (1635-1791) ▼

Slit ----- 52 x 0.2 ▼

1st Order FUV MAMA (see special [MAMA countrate restrictions](#))

- Grating:** **Central Wavelength**
- ☐ G140L (1150 - 1736)
- ☐ G140M c 1222 (1194-1249) ▼

Slit ----- 52 x 0.2 ▼

1st Order NUV MAMA (see special [MAMA countrate restrictions](#))

- Grating** **Cen. Wave.**
- ☐ G230L (1570 - 3180)
- ☐ G230M c 1687 (1642-1732) ▼

Slit ----- 52 x 0.2 ▼

MAMA Echelle

NUV			FUV		
Grating	Cen. Wave.	Slit	Grating	Cen. Wave.	Slit
<input type="radio"/> E230M	c 2707 (2303-3111) ▼	0.2 x 0.2 ▼	<input type="radio"/> E140M	(1150 - 1700)	0.2 x 0.2 ▼
<input type="radio"/> E230H	c 1763 (1624-1901) ▼	0.2 x 0.09 ▼	<input type="radio"/> E140H	c 1234 (1133-1335) ▼	0.2 x 0.09 ▼

MAMA Objective Prism

- ☐ PRISM (NUV MAMA) (1150 - 3000)

Filter ----- 52 x 0.05 ▼

Specify [FUV MAMA glow region](#): Low ▼

Specify additional [CCD parameters](#):

Binning		Gain	# Frames	Dark
Dispersion Axis	Spatial Axis			
1 pixel ▼	1 pixel ▼	1 e-/ADU ▼	2	Medium ▼

Let's practice with 3 examples

Optical spectroscopy of a relatively bright A-type star

WASP-17: hosts one of the most inflated hot Jupiters

Full atmospheric analysis

RA: 15:59:51

DEC: -28:03:43

V = 11.59 mag

Teff = 6600 K

F4V

Optical spectroscopy of a very faint Sun-like star

[GV2003] N: the companion to a neutron star

Get as much information as possible (e.g. Teff, logg, RV, abundances)

RA: 14:40:31

DEC: -62:38:17

V = 20.69 mag

Teff \approx 5200 K

Detection of UV emission lines of a Sun-like star

WASP-18: a low-activity, young star hosting a massive hot Jupiter

Measure the strength of chromospheric lines

RA: 01:37:25

DEC: -45:40:40

V = 9.28 mag

Teff = 6400 K

d = 123 pc

Optical spectroscopy of a relatively bright A-type star

Goal: full atmospheric analysis, that is derive atmospheric parameters and abundances

Requirements:

- High spectral resolution $R > 50\,000$
- High signal to noise ratio $S/N \geq 150$
- As broad as possible wavelength coverage...but which are the features you certainly want to cover?
 - Balmer lines
 - CaI triplet
 - MgI b triplet
- No need of space-based facility
- The negative declination suggests the use of a facility located in the Southern hemisphere

Possibilities:

- ESO: HARPS (La Silla), FEROS (La Silla), **UVES** (Paranal)

Optical spectroscopy of a relatively bright A-type star ETC - UVES

<https://www.eso.org/sci.html>

Observing with ESO telescopes

Observing tools and services

ESO Exposure time calculators

UVES

or

<http://www.eso.org/observing/etc/bin/gen/form?INS.NAME=UVES+INS.MODE=spectro>

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or

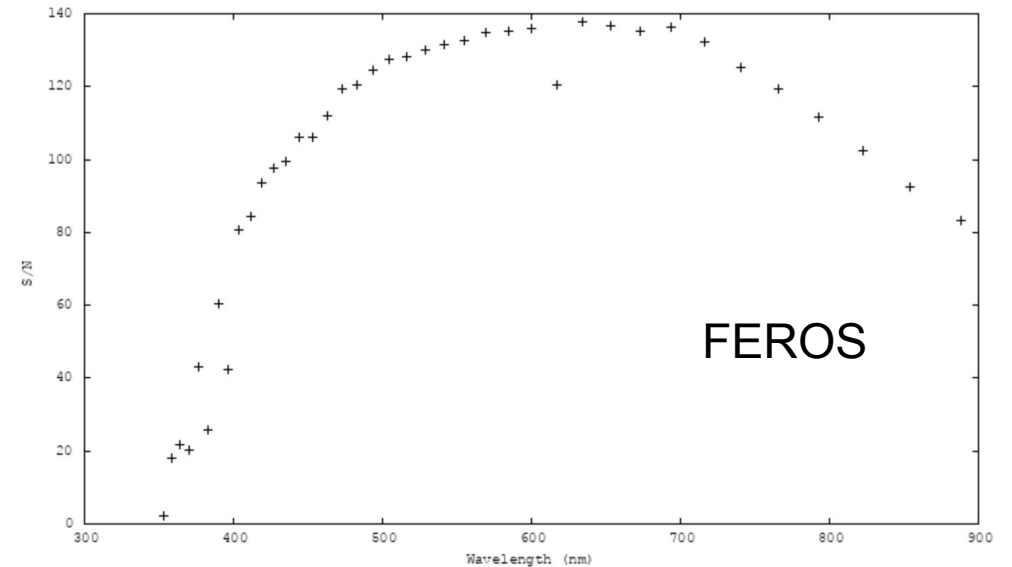
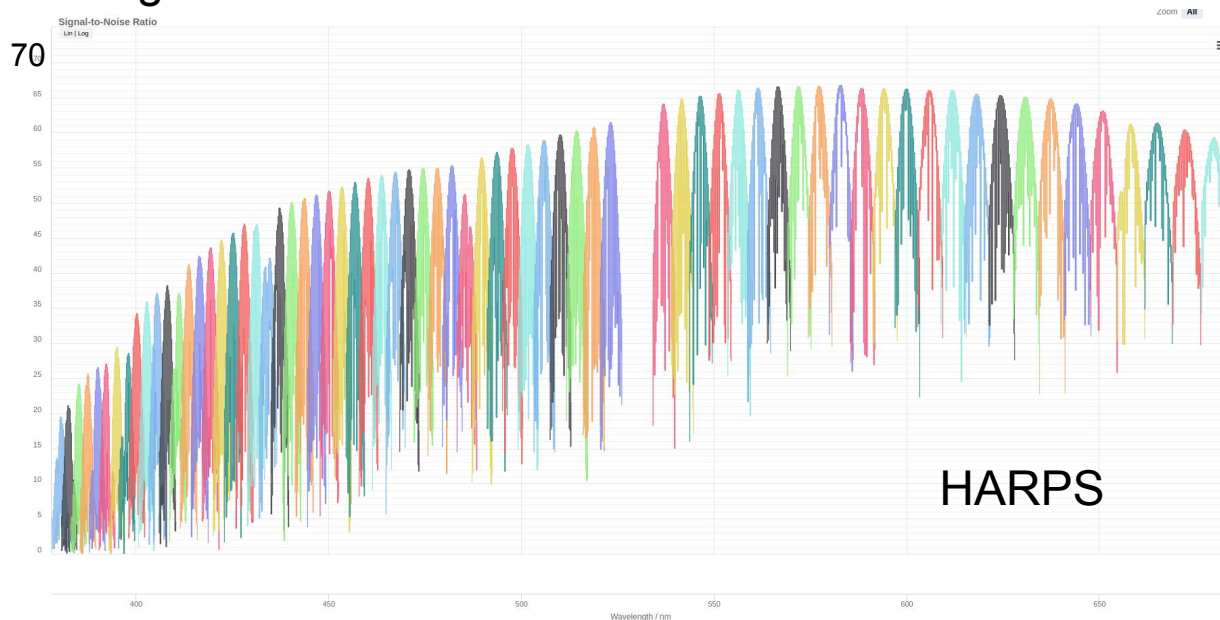
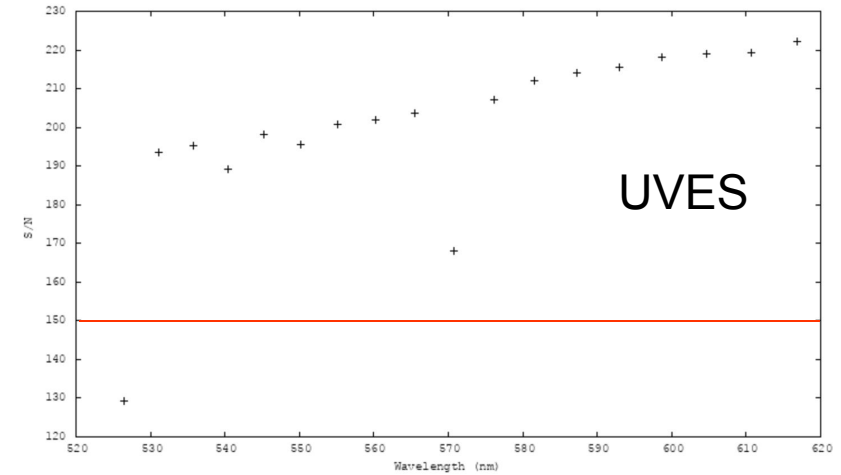
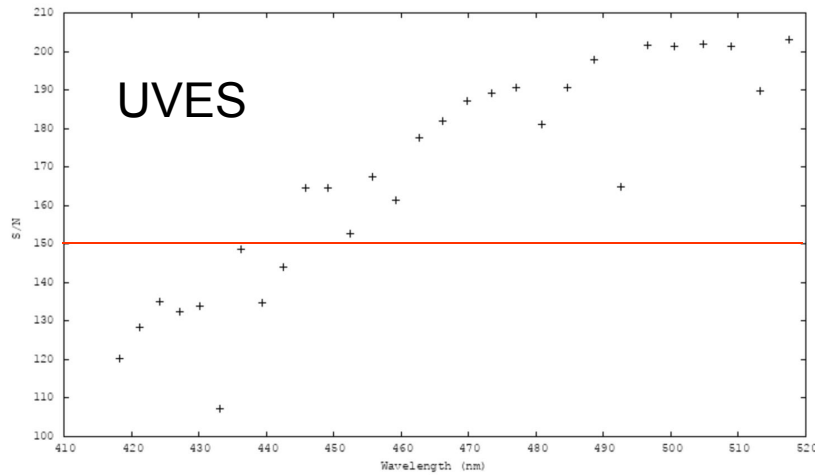
Date (eve) moon			eve		cent		morn		night	hrs@sec.z:		
			HA	sec.z	HA	sec.z	HA	sec.z	<3	<2	<1.5	
2023	Dec	26	F	+10 40	down	-9 38	down	-5 56	4.7	0.0	0.0	0.0
2024	Jan	10	N	+11 41	down	-8 32	down	-4 45	2.2	0.6	0.0	0.0
2024	Jan	25	F	-11 25	down	-7 28	down	-3 32	1.5	1.8	1.0	0.1
2024	Feb	9	N	-10 36	down	-6 27	9.8	-2 18	1.2	3.0	2.2	1.3
2024	Feb	23	F	-9 53	down	-5 33	3.4	-1 12	1.0	4.1	3.3	2.4
2024	Mar	9	N	-9 10	down	-4 37	2.1	-0 03	1.0	5.3	4.4	3.5
2024	Mar	24	F	-8 27	down	-3 42	1.5	+1 03	1.0	6.4	5.6	4.6
2024	Apr	8	N	-7 43	down	-2 47	1.3	+2 08	1.1	7.5	6.6	5.7
2024	Apr	23	F	-6 56	v. low	-1 52	1.1	+3 13	1.4	8.5	7.7	6.8
2024	May	7	N	-6 09	6.1	-0 58	1.0	+4 14	1.8	9.5	8.7	7.2
2024	May	22	F	-5 15	2.8	+0 01	1.0	+5 18	2.9	10.5	9.0	7.2
2024	Jun	5	N	-4 22	1.9	+0 59	1.0	+6 19	7.7	9.7	8.9	7.2
2024	Jun	21	F	-3 16	1.4	+2 05	1.1	+7 26	down	8.6	7.8	6.9
2024	Jul	5	N	-2 17	1.2	+3 03	1.3	+8 23	down	7.6	6.8	5.9
2024	Jul	20	F	-1 13	1.0	+4 04	1.7	+9 20	down	6.5	5.7	4.8
2024	Aug	3	N	-0 13	1.0	+4 59	2.4	+10 10	down	5.5	4.7	3.8
2024	Aug	19	F	+0 55	1.0	+5 59	5.0	+11 02	down	4.4	3.6	2.7
2024	Sep	2	N	+1 55	1.1	+6 50	43.8	+11 45	down	3.4	2.6	1.7
2024	Sep	17	F	+2 59	1.3	+7 44	down	-11 32	down	2.3	1.5	0.6
2024	Oct	2	N	+4 05	1.7	+8 38	down	-10 49	down	1.3	0.4	0.0
2024	Oct	16	F	+5 08	2.7	+9 29	down	-10 09	down	0.2	0.0	0.0
2024	Oct	31	N	+6 18	7.5	+10 27	down	-9 25	down	0.0	0.0	0.0
2024	Nov	15	F	+7 31	down	+11 27	down	-8 36	down	0.0	0.0	0.0
2024	Nov	30	N	+8 43	down	-11 29	down	-7 42	down	0.0	0.0	0.0
2024	Dec	14	F	+9 50	down	-10 28	down	-6 46	26.2	0.0	0.0	0.0
2024	Dec	30	N	+11 00	down	-9 17	down	-5 34	3.5	0.0	0.0	0.0
2025	Jan	13	F	+11 55	down	-8 16	down	-4 27	1.9	0.9	0.1	0.0

<http://www.eso.org/observing/etc/bin/gen/form?INS.NAME=UVES+INS.MODE=spectro>

Optical spectroscopy of a relatively bright A-type star

Same sky and exposure time settings for the 3 instruments.
Comparable R.

At a given exposure time, with UVES one loses in spectral coverage, but gains in S/N, while with the other instruments one loses in S/N, but gains in spectral coverage.



Optical spectroscopy of a very faint Sun-like star

Goal: gain as much information as possible about the star

Requirements:

- As high as possible spectral resolution
- As high as possible signal to noise ratio
- Observing time to get a decent spectrum possibly within 1 hour
- As broad as possible wavelength coverage...but certainly cover
 - Balmer lines
- The negative declination suggests the use of a facility located in the Southern hemisphere
- The faint magnitude suggests that we need the VLT (8 m class mirror)

Possibilities:

- ESO: UVES, **X-SHOOTER**, FORS2

Optical spectroscopy of a very faint Sun-like star

ETC X-SHOOTER

<https://www.eso.org/sci.html>

Observing with ESO telescopes

Observing tools and services

ESO Exposure time calculators

X-SHOOTER

or

Date (eve)			moon		eve		cent		morn		night		hrs@sec.z:		
					HA	sec.z	HA	sec.z	HA	sec.z	<3	<2	<1.5		
2023	Dec	26	F	+11	58	down	-8	20	7.6	-4	38	1.9	1.7	0.2	0.0
2024	Jan	10	N	-11	01	down	-7	14	4.2	-3	27	1.6	2.9	1.3	0.0
2024	Jan	25	F	-10	07	v.low	-6	10	2.8	-2	13	1.4	4.1	2.6	0.7
2024	Feb	9	N	-9	18	18.4	-5	09	2.2	-1	00	1.3	5.3	3.8	2.0
2024	Feb	23	F	-8	35	9.1	-4	15	1.8	+0	06	1.3	6.4	4.9	3.1
2024	Mar	9	N	-7	52	5.7	-3	19	1.6	+1	15	1.3	7.6	6.0	4.2
2024	Mar	24	F	-7	09	4.0	-2	24	1.4	+2	21	1.4	8.7	7.1	5.3
2024	Apr	8	N	-6	25	3.1	-1	29	1.3	+3	26	1.6	9.8	8.2	5.9
2024	Apr	23	F	-5	38	2.4	-0	34	1.3	+4	31	1.9	10.1	9.3	5.9
2024	May	7	N	-4	51	2.0	+0	20	1.3	+5	32	2.4	10.4	9.6	5.9
2024	May	22	F	-3	57	1.7	+1	20	1.3	+6	37	3.3	10.3	8.7	5.9
2024	Jun	5	N	-3	04	1.5	+2	17	1.4	+7	37	5.0	9.4	7.8	5.9
2024	Jun	21	F	-1	58	1.4	+3	23	1.6	+8	44	10.3	8.3	6.7	4.9
2024	Jul	5	N	-0	59	1.3	+4	21	1.8	+9	41	35.4	7.3	5.8	3.9
2024	Jul	20	F	+0	05	1.3	+5	22	2.3	+10	38	down	6.2	4.7	2.9
2024	Aug	3	N	+1	05	1.3	+6	17	2.9	+11	28	down	5.2	3.7	1.9
2024	Aug	19	F	+2	14	1.4	+7	17	4.3	-11	40	down	4.1	2.6	0.7
2024	Sep	2	N	+3	13	1.5	+8	08	6.7	-10	57	down	3.1	1.6	0.0
2024	Sep	17	F	+4	17	1.8	+9	02	13.6	-10	14	down	2.0	0.5	0.0
2024	Oct	2	N	+5	23	2.3	+9	56	74.0	-9	31	25.9	1.0	0.0	0.0
2024	Oct	16	F	+6	26	3.1	+10	48	down	-8	51	11.5	0.0	0.0	0.0
2024	Oct	31	N	+7	36	5.0	+11	45	down	-8	07	6.6	0.0	0.0	0.0
2024	Nov	15	F	+8	49	11.0	-11	15	down	-7	18	4.3	0.0	0.0	0.0
2024	Nov	30	N	+10	02	v.low	-10	11	v.low	-6	24	3.1	0.0	0.0	0.0
2024	Dec	14	F	+11	08	down	-9	10	15.7	-5	28	2.3	0.9	0.0	0.0
2024	Dec	30	N	-11	42	down	-7	59	6.1	-4	16	1.8	2.1	0.5	0.0
2025	Jan	13	F	-10	47	down	-6	58	3.8	-3	09	1.5	3.2	1.6	0.0

<http://www.eso.org/observing/etc/bin/gen/form?INS.NAME=X-SHOOTER+INS.MODE=spectro>

Optical spectroscopy of a very faint Sun-like star

Same sky and exposure time settings for the 3 instruments.

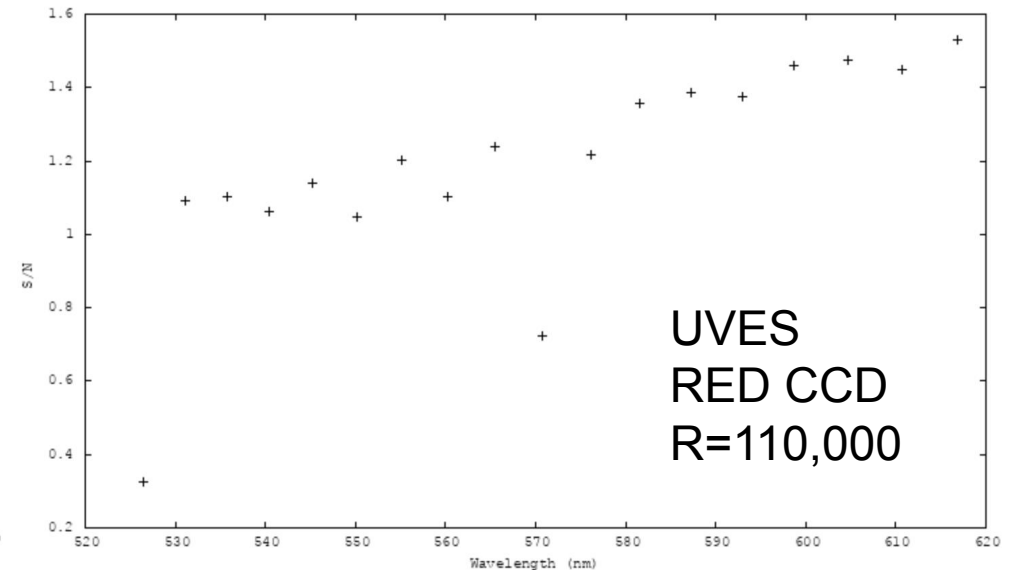
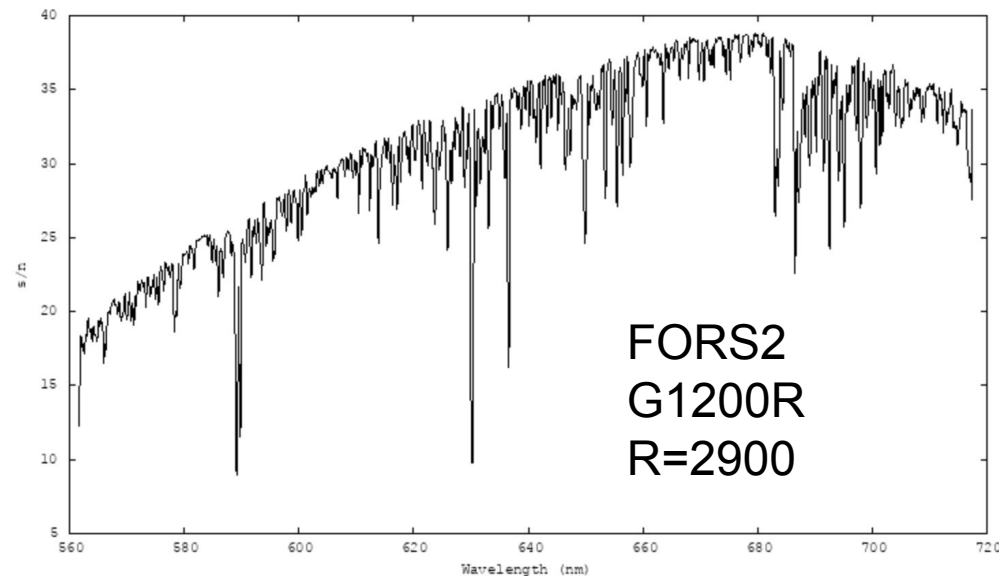
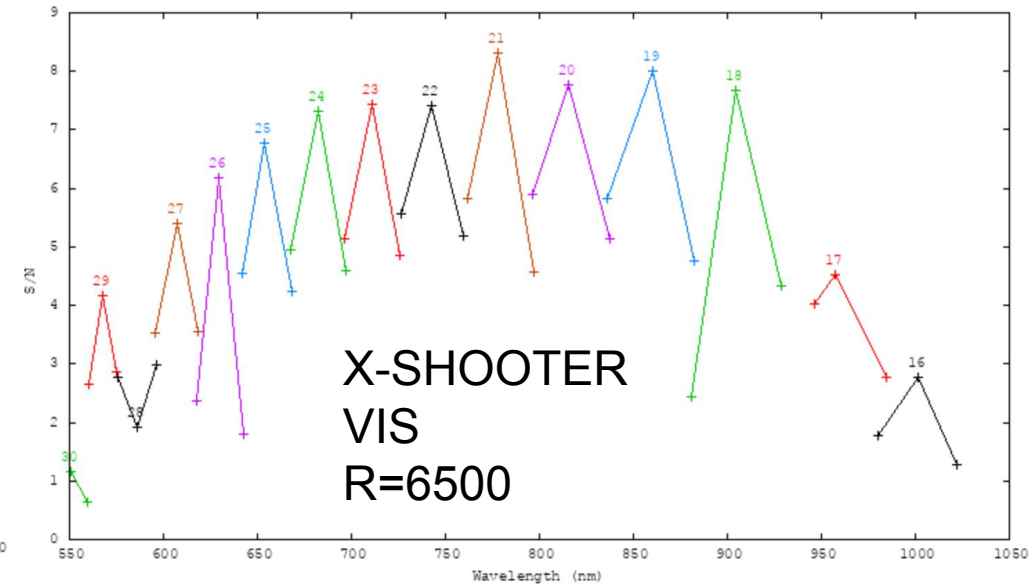
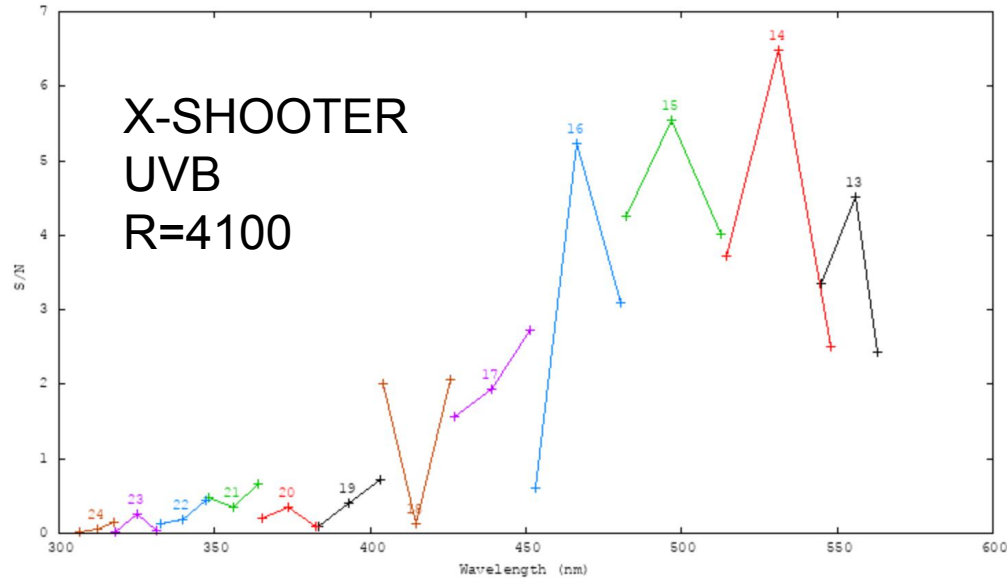
Here, one has to compromise between S/N and spectral resolution.

What is better?

Higher R and lower S/N?

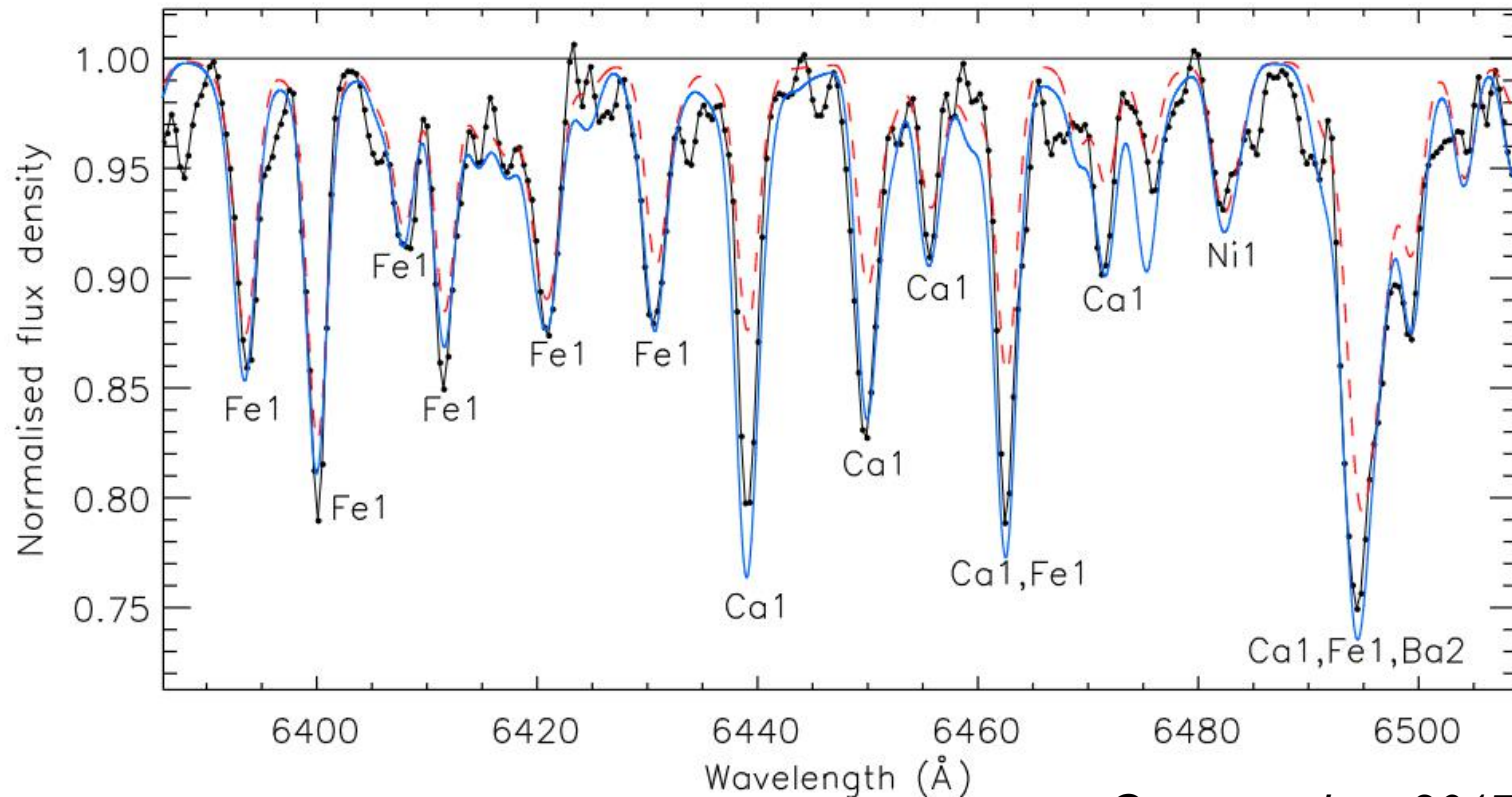
Higher S/N and lower R?

In this case, the choice is: higher S/N and lower R.



Optical spectroscopy of a very faint Sun-like star

How the actual FORS2 spectrum looks like



Gvaramadze+2017

However, when writing the observing proposal, you have to justify why you have chosen FORS2. This is done by taking a synthetic spectrum of the target, convolve it at the instrumental spectral resolution, and adding noise following what the ETC has given.

Then you show the simulation and demonstrate, for example, that with this S/N and resolution you can measure T_{eff} from the H α line with XYZ K uncertainty.

Detection of UV emission lines of a Sun-like star

Goal: detect and measure the strength of chromospheric emission lines

Requirements:

- As high as possible (at all costs) signal to noise ratio
Peak $S/N \geq 5-10$ is typically enough to detect a feature at >3 sigma when integrating the flux
- As broad as possible wavelength coverage to measure as many lines as possible
- UV wavelengths -> space-based observation
- Far-UV wavelengths: where most of the strong resonance lines of abundant elements are located

Possibilities:

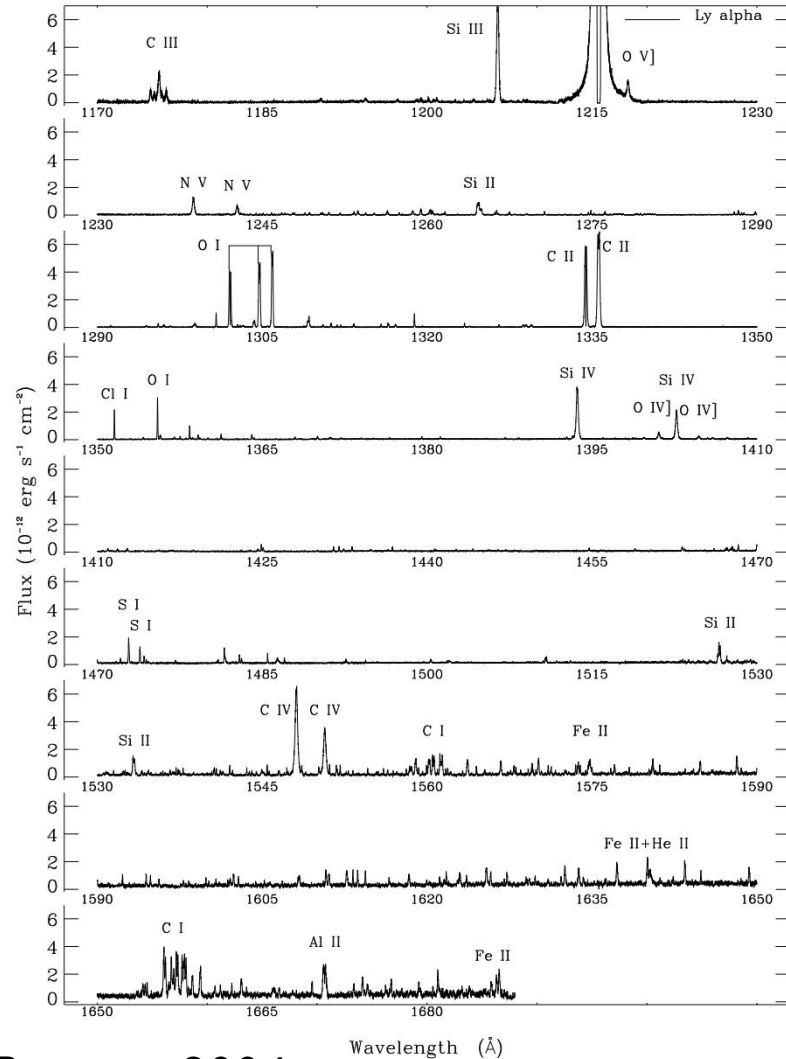
- HST: STIS, **COS**

Detection of UV emission lines of a Sun-like star
How does the stellar spectrum look like?

Detection of UV emission lines of a Sun-like star

How does the stellar spectrum look like?

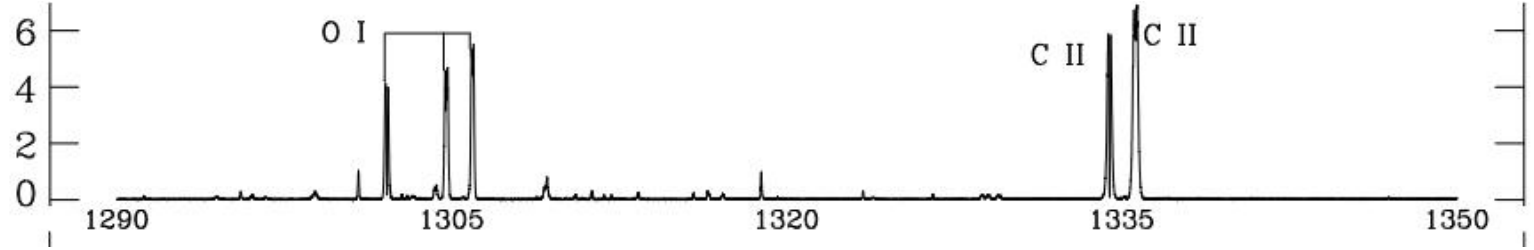
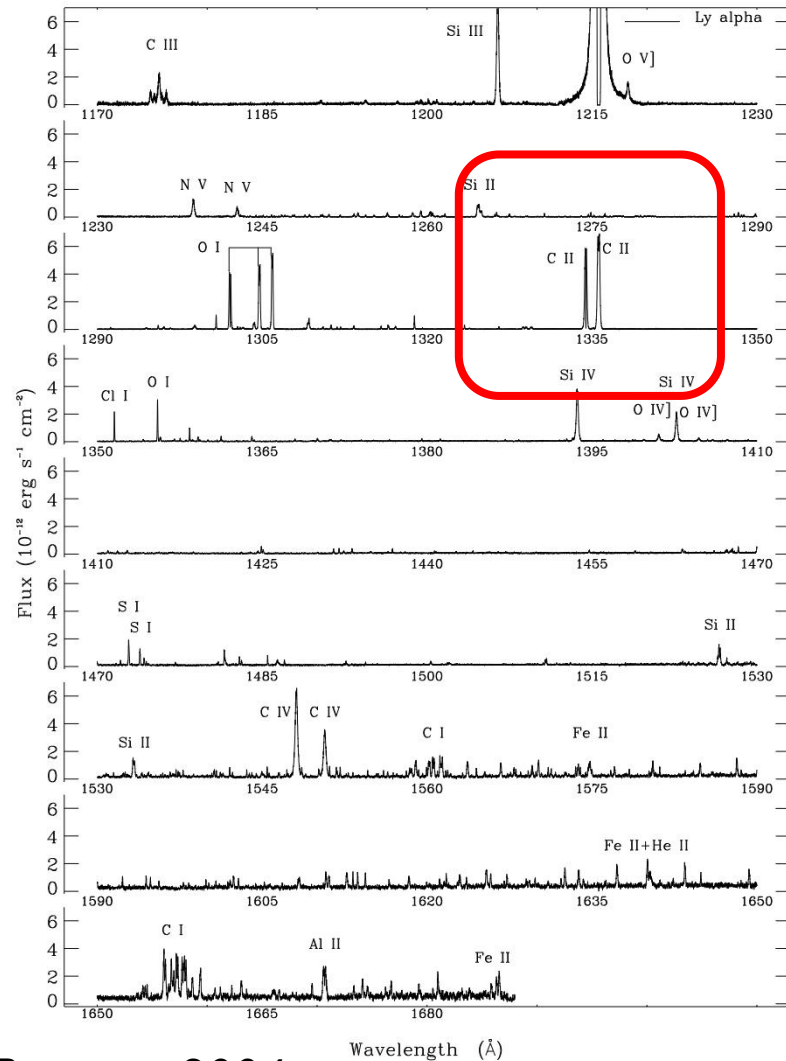
alpha Cen A



Detection of UV emission lines of a Sun-like star

How does the stellar spectrum look like?

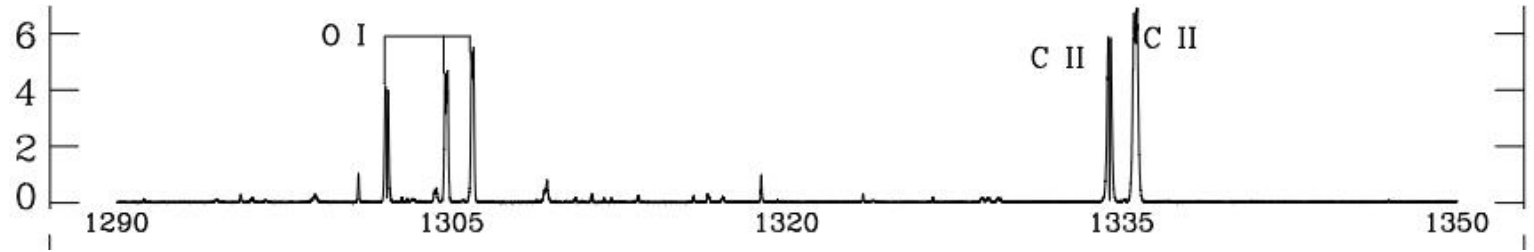
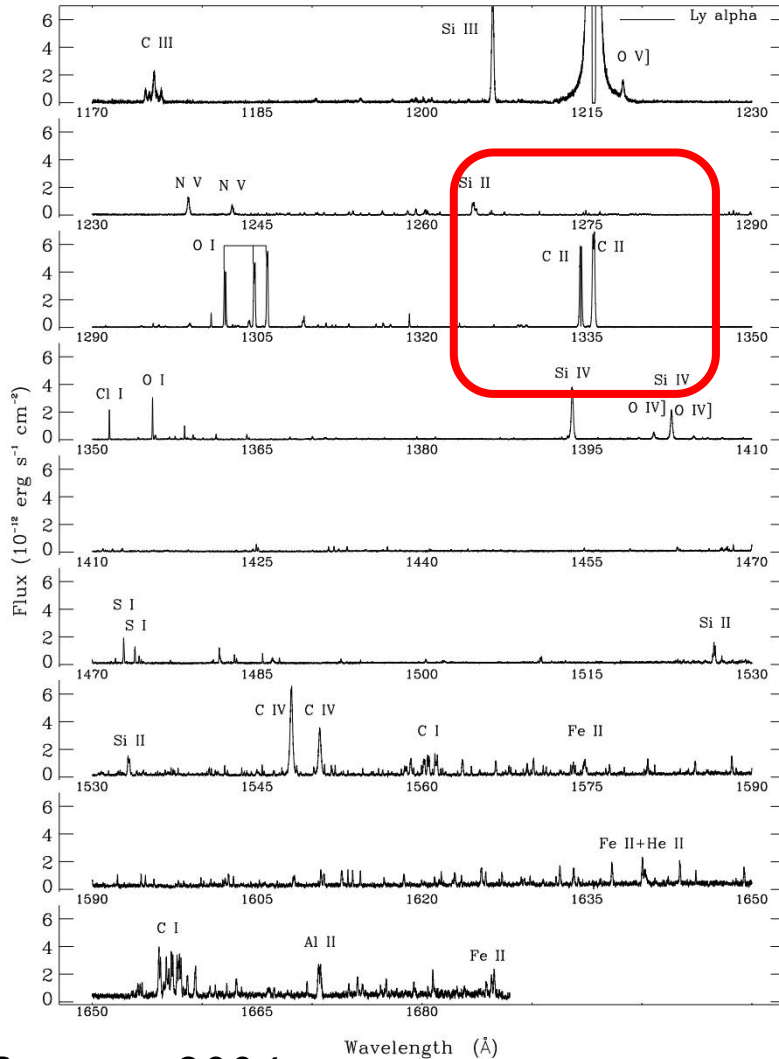
alpha Cen A



Detection of UV emission lines of a Sun-like star

How does the stellar spectrum look like?

alpha Cen A



Why CII lines?

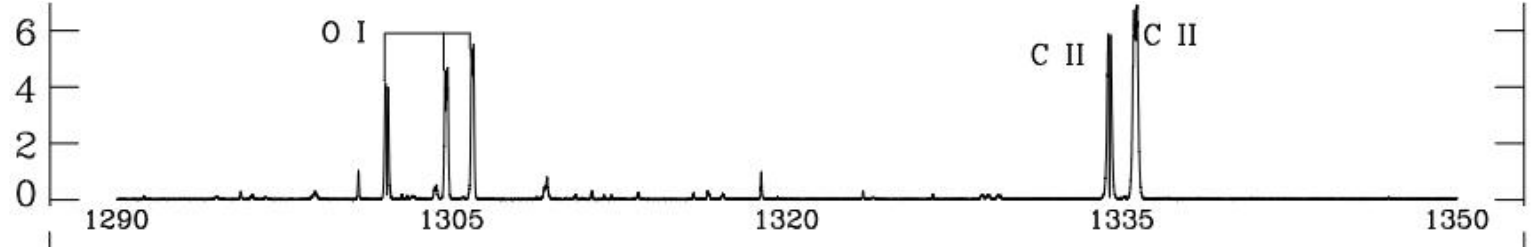
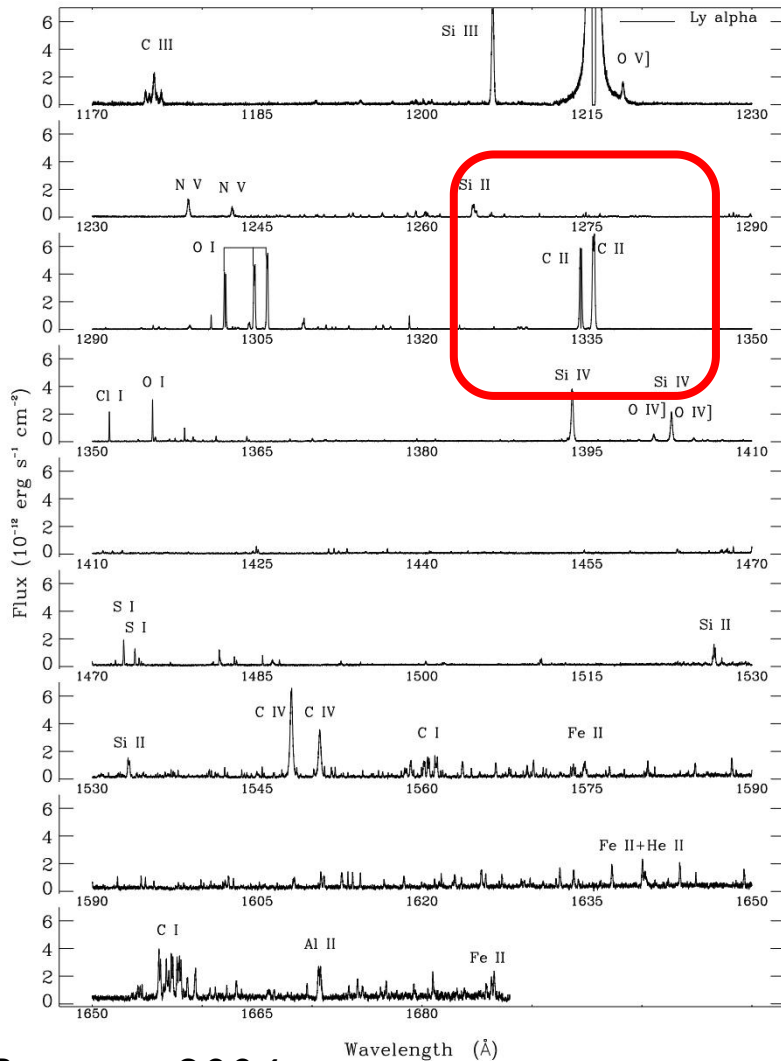
- Strongest features together with Ly alpha, OI, and CIV
- But, when observing with COS, Ly alpha and OI are contaminated by geocoronal emission
- But, if the star is really very inactive, the CIV lines are going to be very weak, while the CII lines are going to be relatively strong regardless of the activity of the star

You have to know the physics of what you are looking at and the characteristics of the instrument you want to use!

Detection of UV emission lines of a Sun-like star

How does the stellar spectrum look like?

alpha Cen A

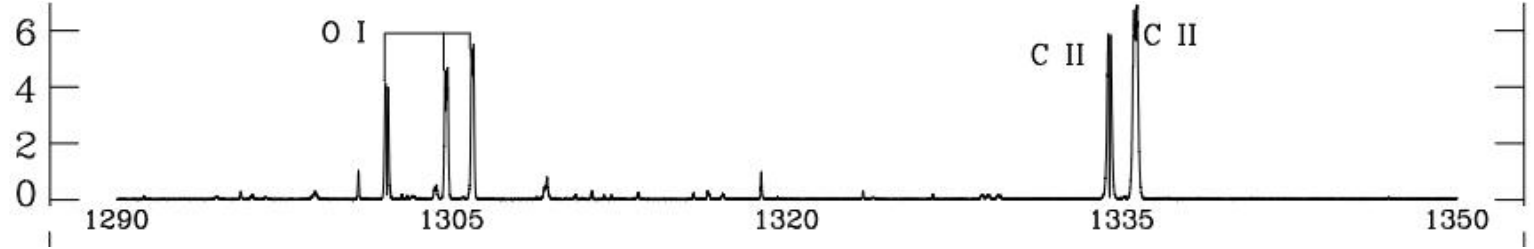
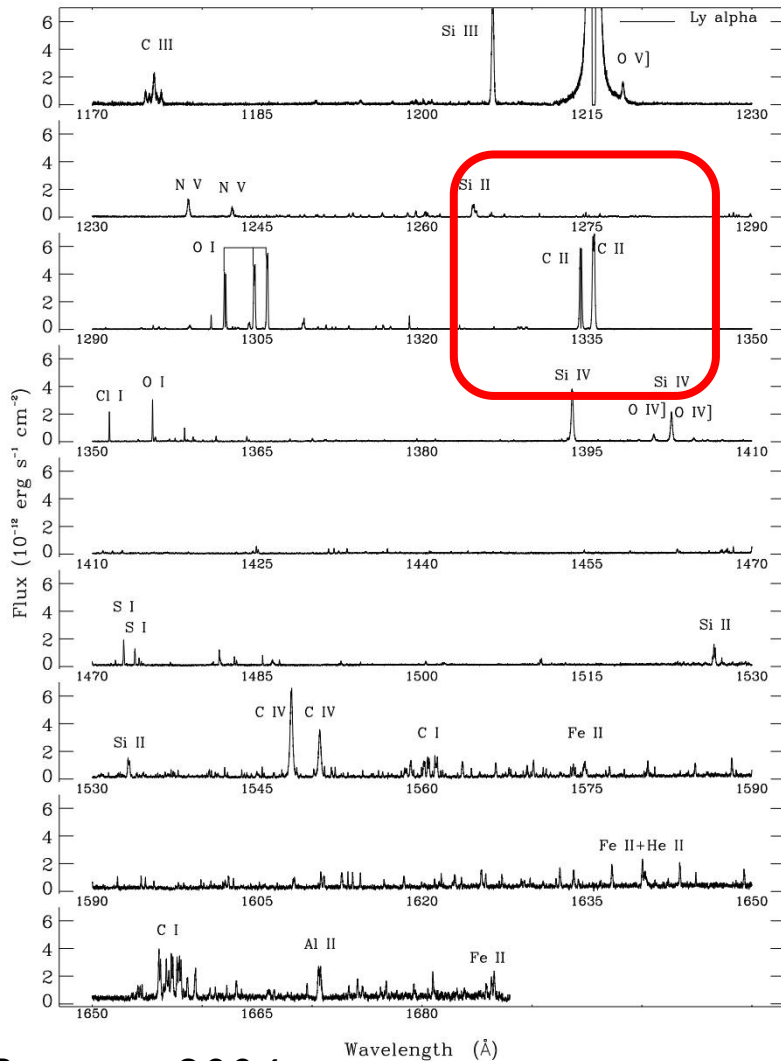


- Line peak at about $6 \times 10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$
- Line width of about 0.8 Angstroms
- Rescale the peak flux by the distances of alpha Cen A (1.32 pc) and WASP-18 (100 pc) --> peak flux of about $10^{-15} \text{ erg cm}^{-2} \text{ s}^{-1}$
- Account for possible ISM absorption --> divide peak flux by 5

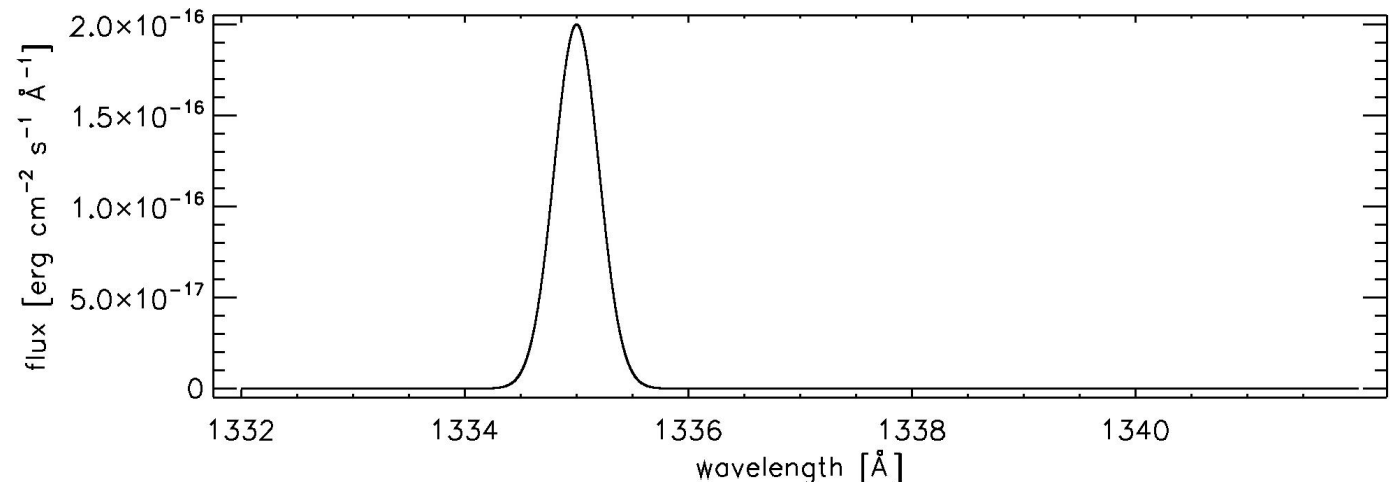
Detection of UV emission lines of a Sun-like star

How does the stellar spectrum look like?

alpha Cen A



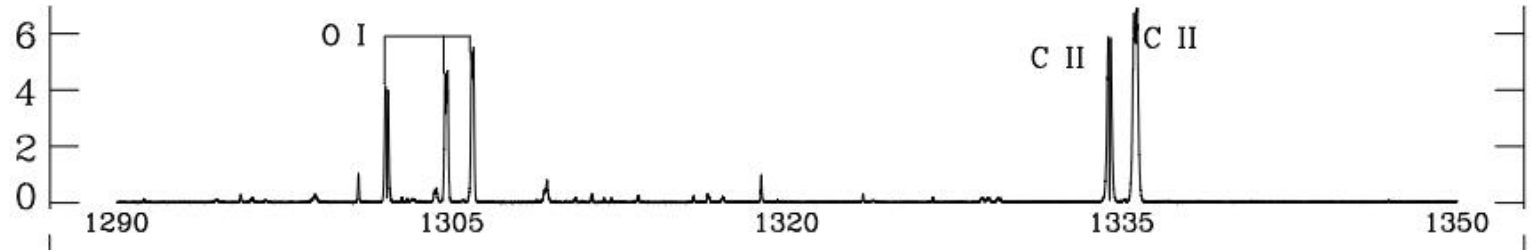
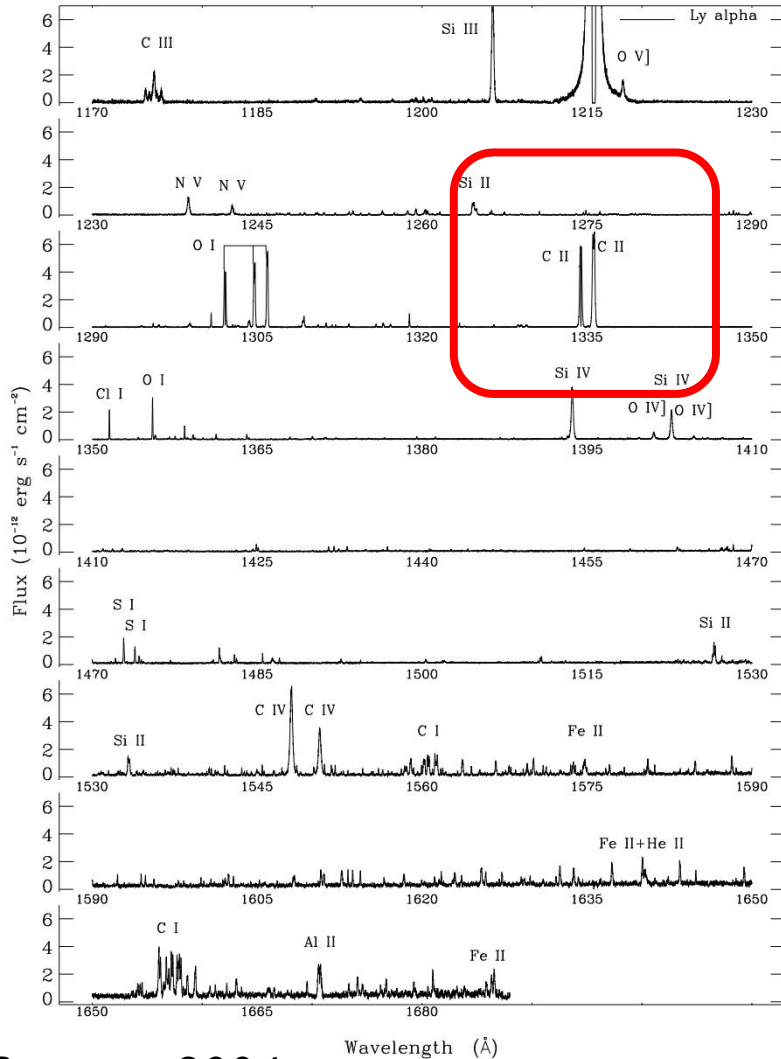
- Line peak at about 6×10^{-12} erg cm^{-2} s^{-1}
- Line width of about 0.8 Angstroms
- Rescale the peak flux by the distances of alpha Cen A (1.32 pc) and WASP-18 (100 pc) --> peak flux of about 10^{-15} erg cm^{-2} s^{-1}
- Account for possible ISM absorption --> divide peak flux by 5



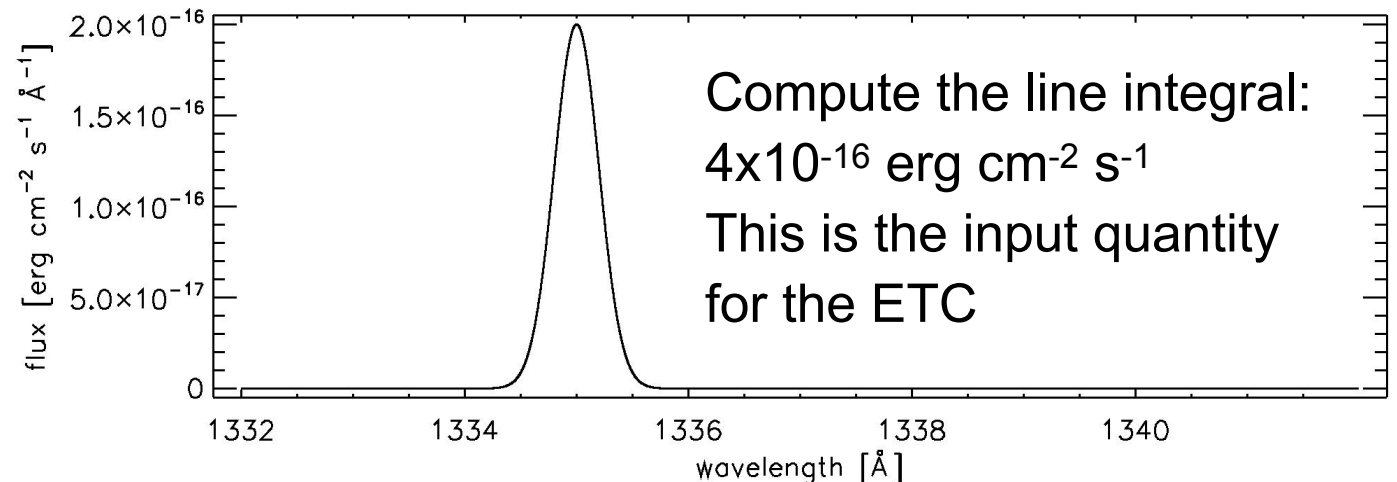
Detection of UV emission lines of a Sun-like star

How does the stellar spectrum look like?

alpha Cen A



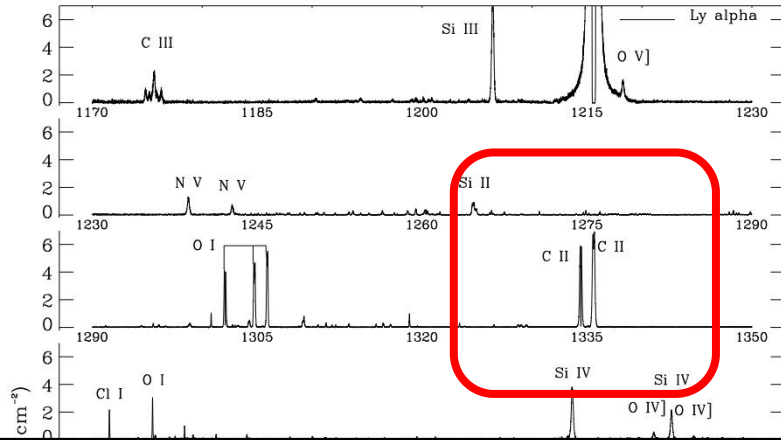
- Line peak at about 6×10^{-12} erg cm $^{-2}$ s $^{-1}$
- Line width of about 0.8 Angstroms
- Rescale the peak flux by the distances of alpha Cen A (1.32 pc) and WASP-18 (100 pc) --> peak flux of about 10^{-15} erg cm $^{-2}$ s $^{-1}$
- Account for possible ISM absorption --> divide peak flux by 5



Detection of UV emission lines of a Sun-like star

How does the stellar spectrum look like?

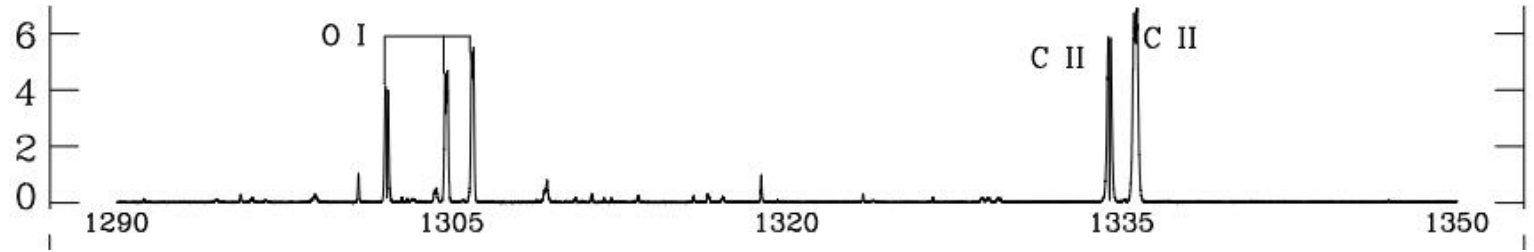
alpha Cen A



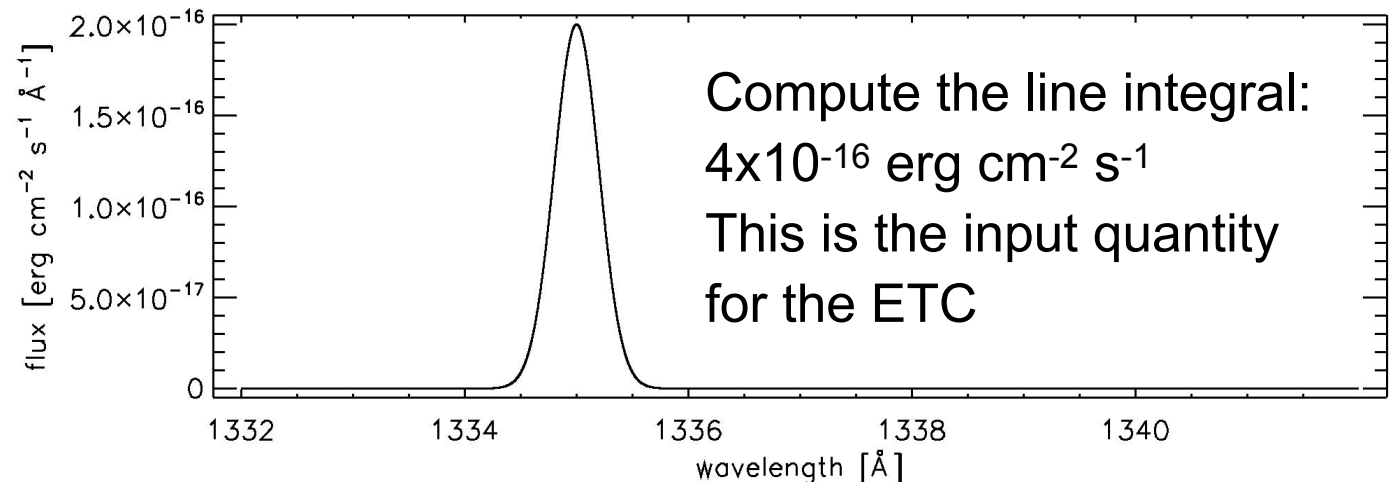
This is a doublet and, at the low resolution of the G140L grating, the two lines will not be resolved, which means that I can roughly double this flux:

$$8 \times 10^{-16} \text{ erg cm}^{-2} \text{ s}^{-1}$$

Lots of guess-work, but not much else can be done



- Line peak at about $6 \times 10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$
- Line width of about 0.8 Angstroms
- Rescale the peak flux by the distances of alpha Cen A (1.32 pc) and WASP-18 (100 pc) --> peak flux of about $10^{-15} \text{ erg cm}^{-2} \text{ s}^{-1}$
- Account for possible ISM absorption --> divide peak flux by 5



Detection of UV emission lines of a Sun-like star

ETC COS

<https://etc.stsci.edu/>

Cosmic Origins Spectrograph (COS) ETCs
Spectroscopy

or

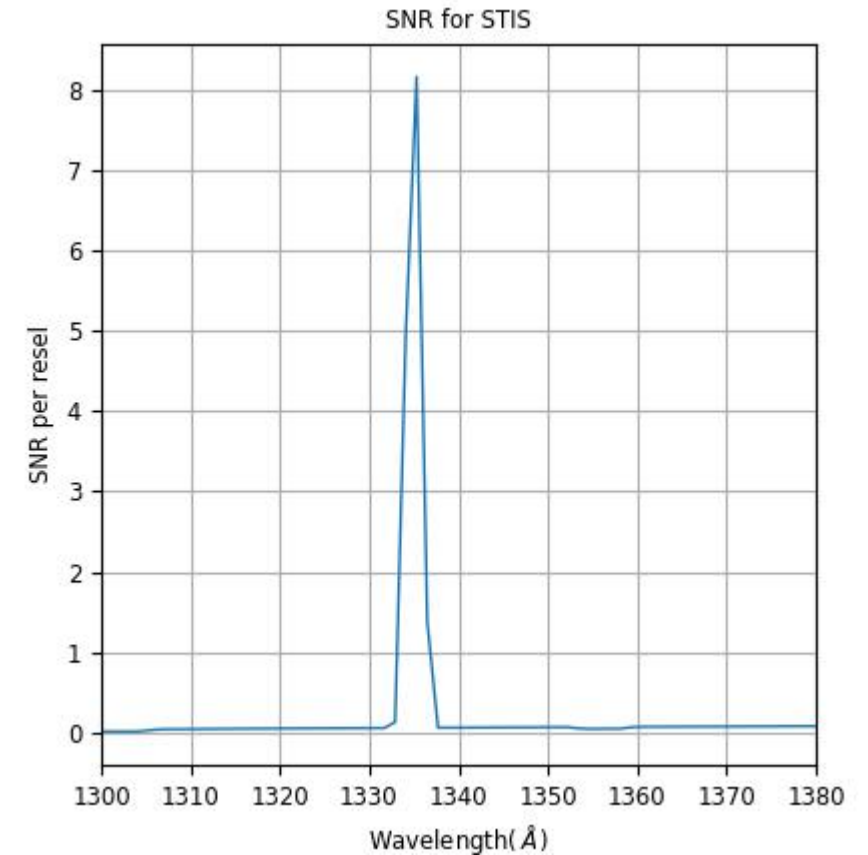
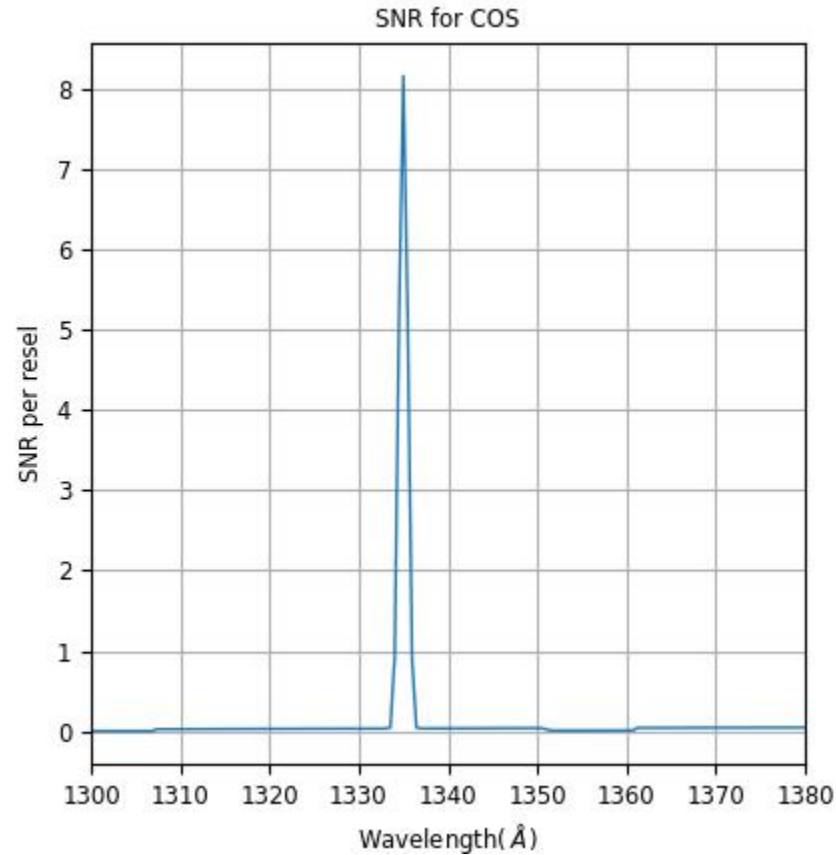
<https://etc.stsci.edu/etc/input/cos/spectroscopic/>

Detection of UV emission lines of a Sun-like star

Same stellar emission and exposure time.
Comparable gratings.

I got the same S/N!

- Are they comparable?
- Can I then pick either instrument?



Detection of UV emission lines of a Sun-like star

Same stellar
emission and
exposure time.
Comparable
gratings.

STIS

Detailed Information		Count rate
		(counts/s)
Counts (box 11 pixels high)		(1 pix x 11 pix)
Source		0.013
Background		8.250e-04
Sky		2.653e-12
Dark Current		8.250e-04

I got the same S/N!

- Are they comparable?
- Can I then pick either instrument?

COS

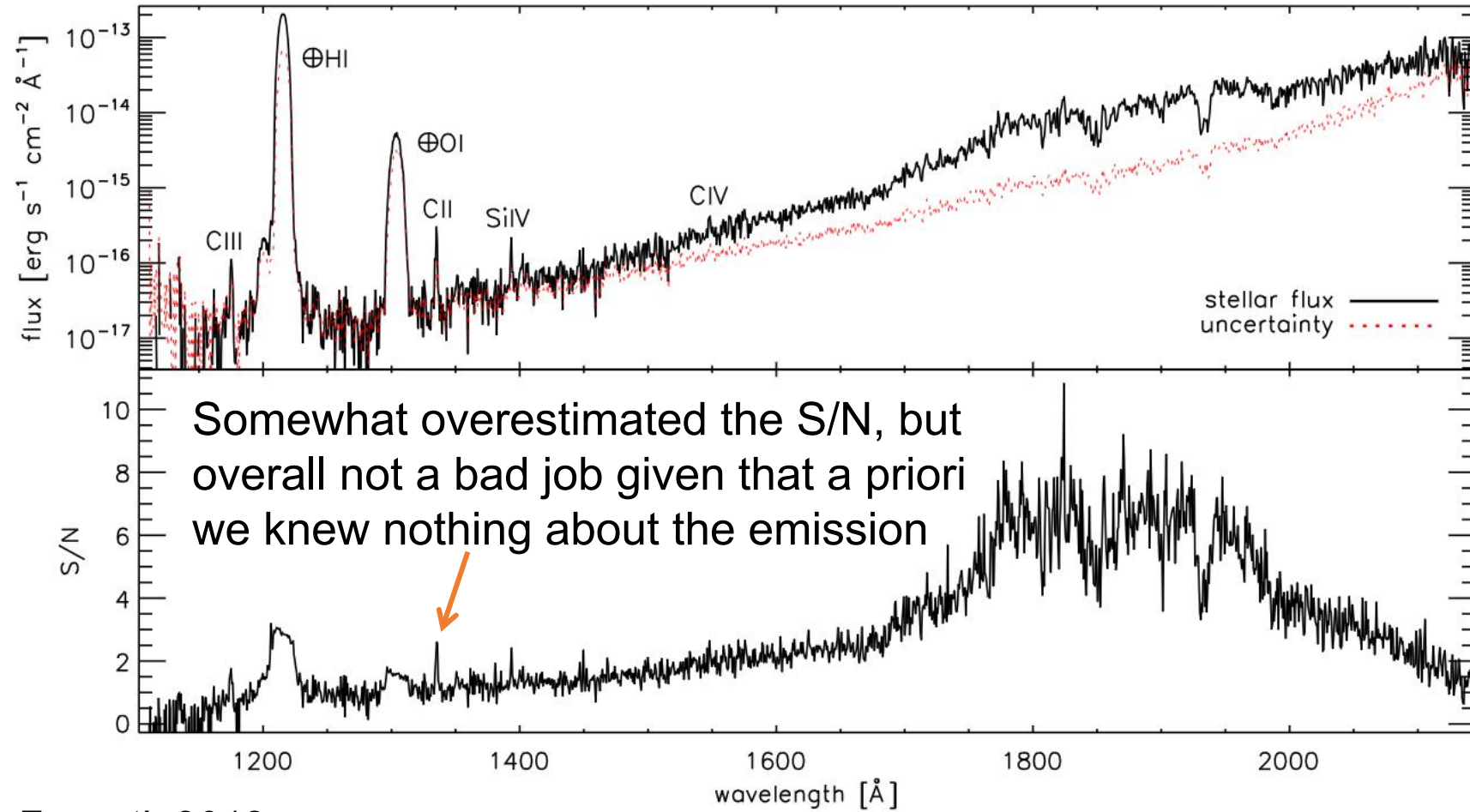
Detailed Information		Count rate
		(counts/s)
Counts (box 57 pixels high)		(1 pix x 57 pix)
Source		0.004
Background		1.932e-04
Sky		2.040e-11
Dark Current		1.932e-04

No!

You have to know
the instrument!

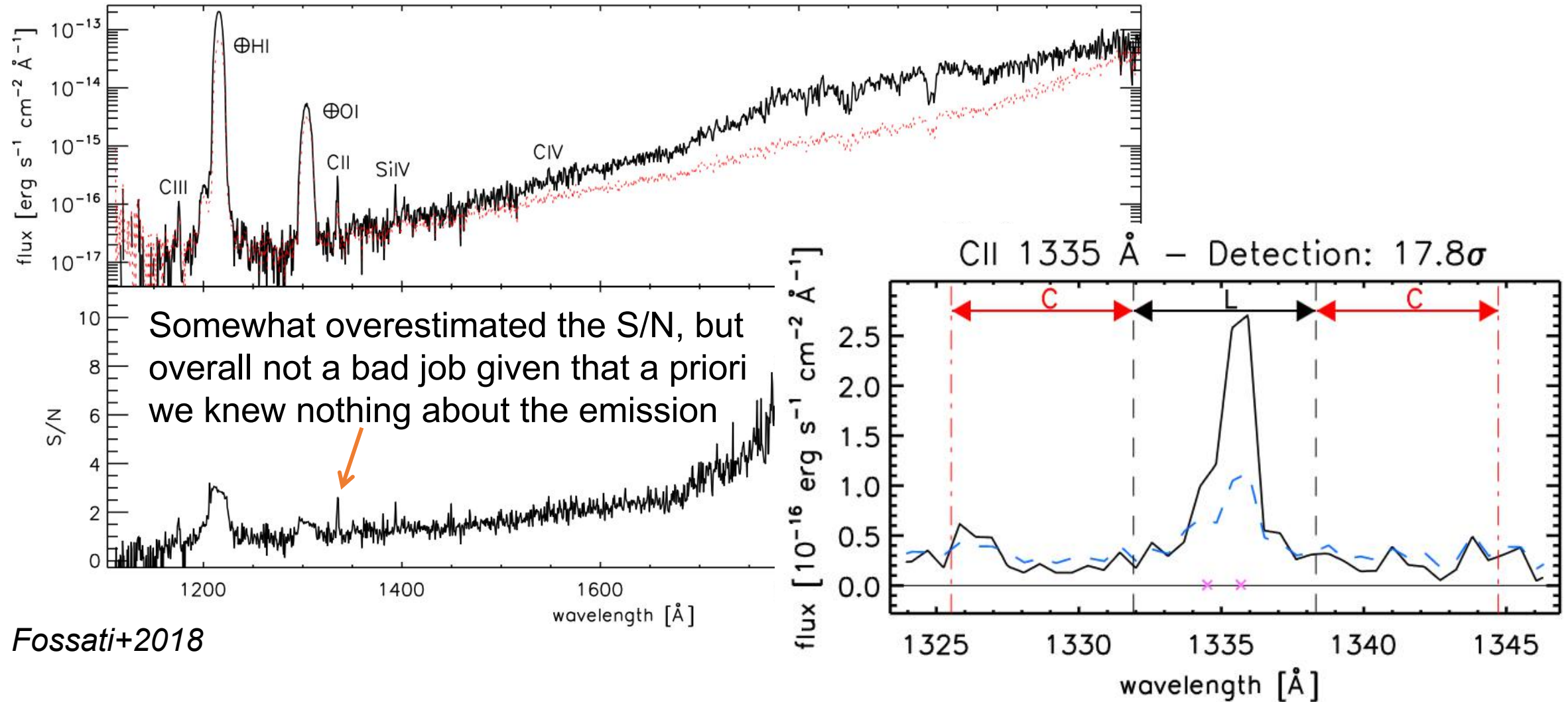
COS has a significantly lower background compared to STIS that will allow you to detect also weaker features, which is exactly the goal of the observations

Detection of UV emission lines of a Sun-like star



Fossati+2018

Detection of UV emission lines of a Sun-like star



Fossati+2018